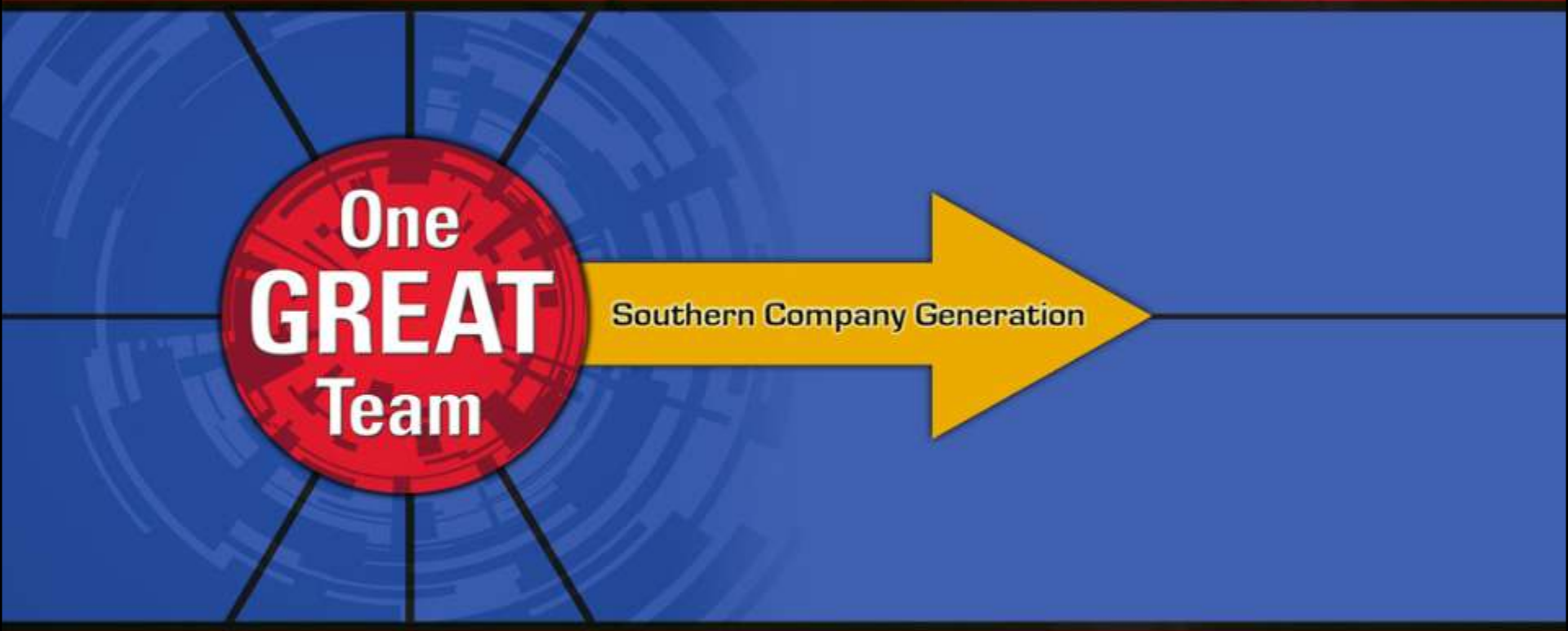
ADEM Groundwater Conference June 8, 2011

SOUTHERN COMPANY



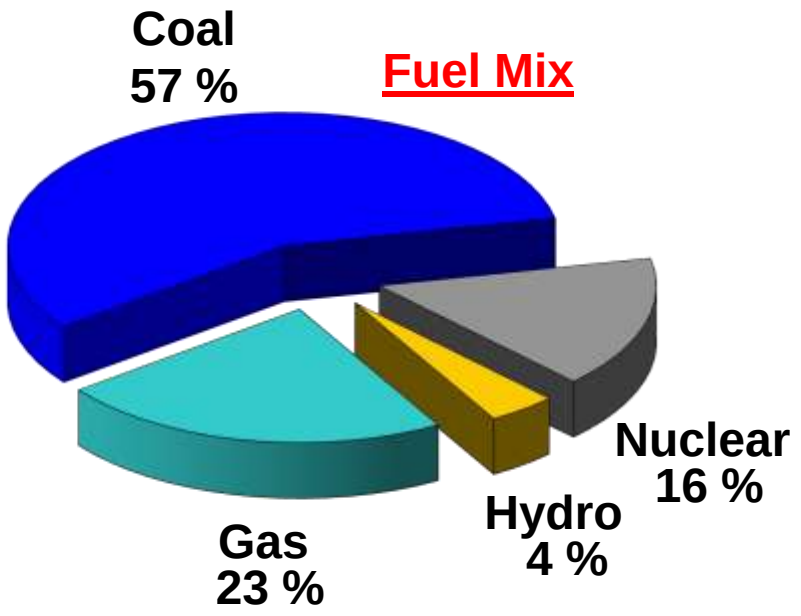
Carbon Capture and Geologic Sequestration

Southern Company Research & Development in support of Commercial Deployment

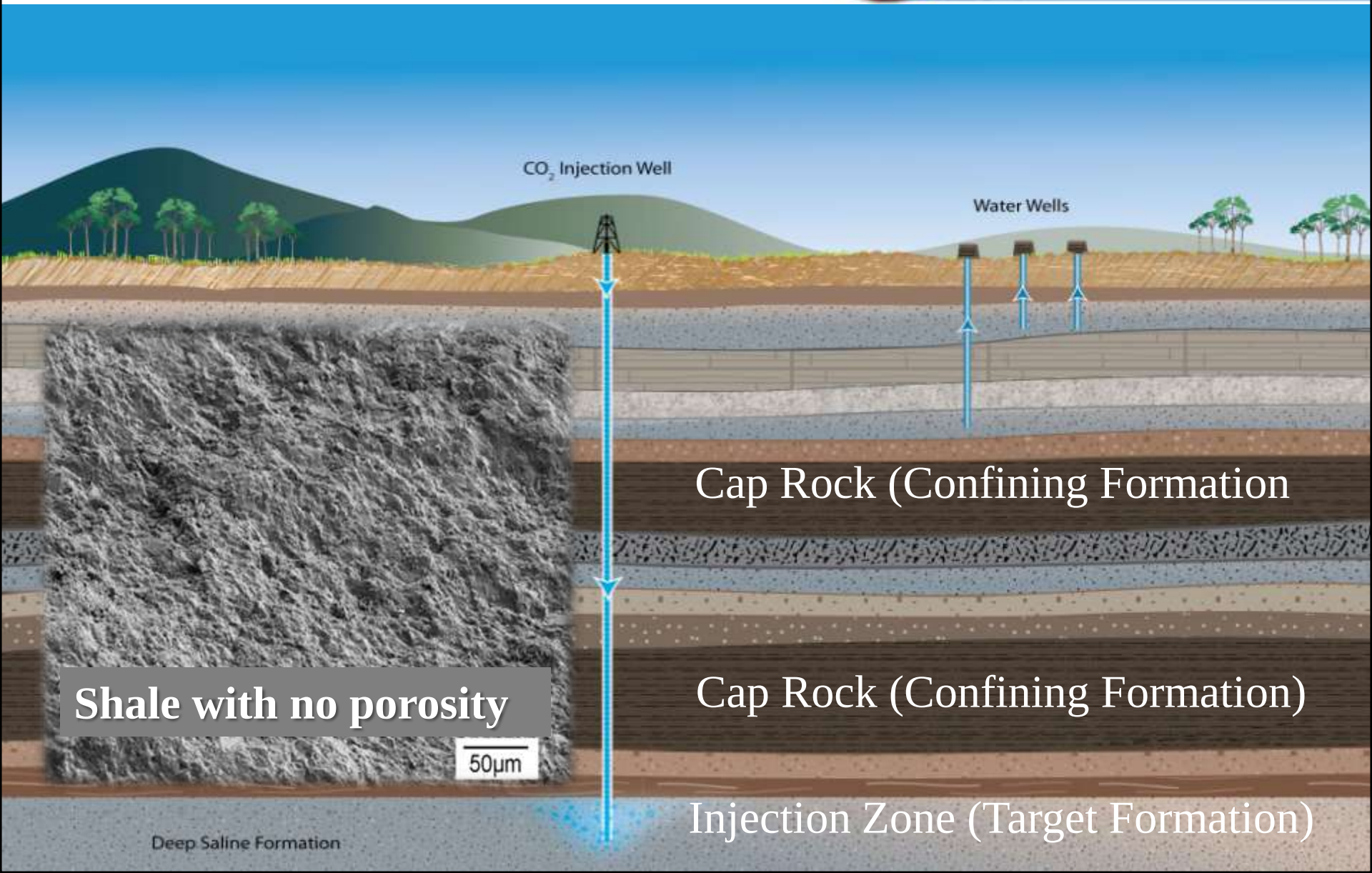
By Richard A. Esposito, PhD

Southern Company (NYSE:SO)

- Regional energy company
  - Alabama, Georgia, Gulf, Mississippi, and Southern Nuclear
  - Southern Power - largest wholesale power producer in the Southeast
  - Southern Company Services - in house engineering & research services
  - More than 46,000 MW of electric generating capacity (79 plants)
- Core service area
  - 120,000 square miles in four southeastern states
  - 4.4 million customers and 26,000 employees
- One of the largest producers of electricity in the U.S. and the largest user of coal



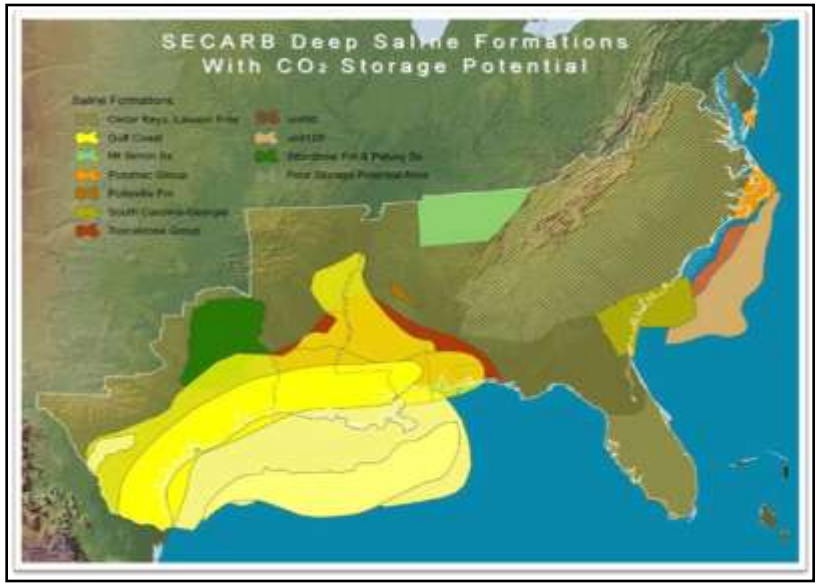
Geologic sequestration

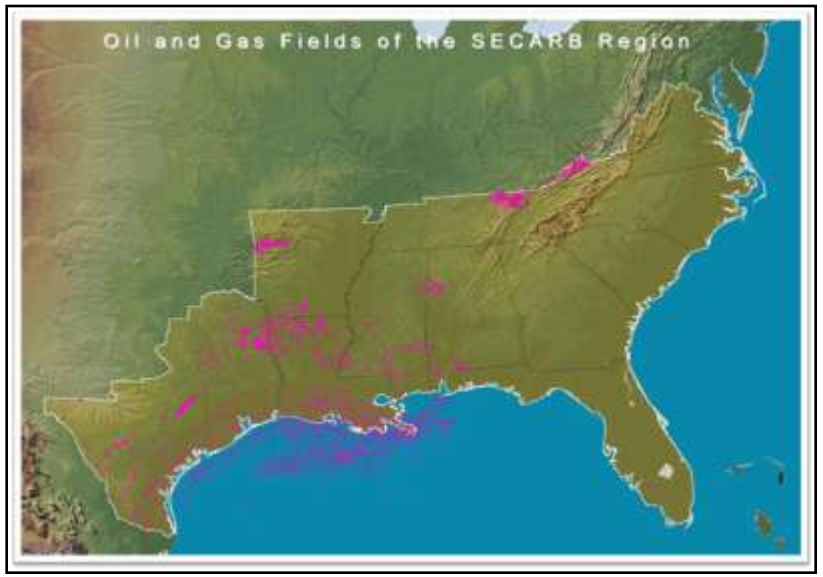


Diverse storage options

- Deep saline formations
- Storage in oil fields associated with CO_2-EOR
- Storage in coal seams associated with CO_2-ECBM
- Depleted oil and gas fields
- Unconventional reservoirs such as basalt and shale
- Sub-sea bed formations

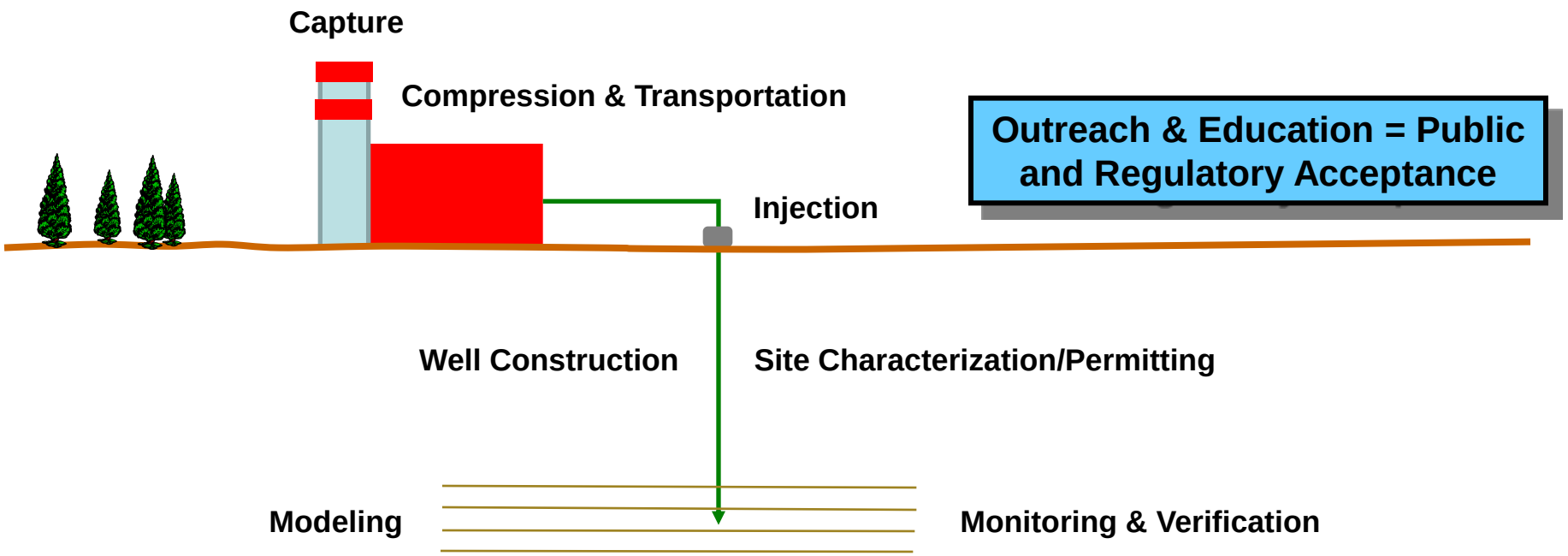
Southeast storage capacity exceeds 2 trillion tons and provides > 1,000 years of storage for all source emissions in the region

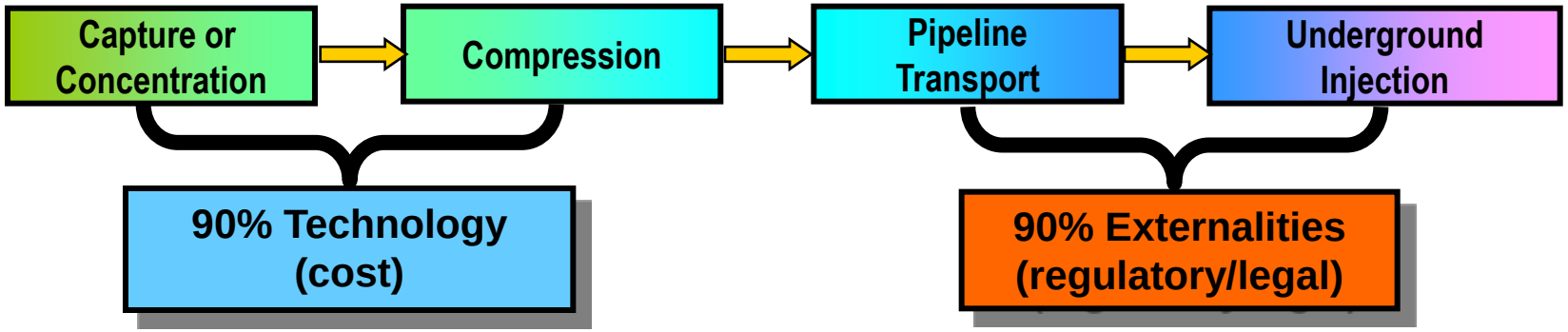




Carbon Capture and Storage

One GREAT Team — Southern Company Generation



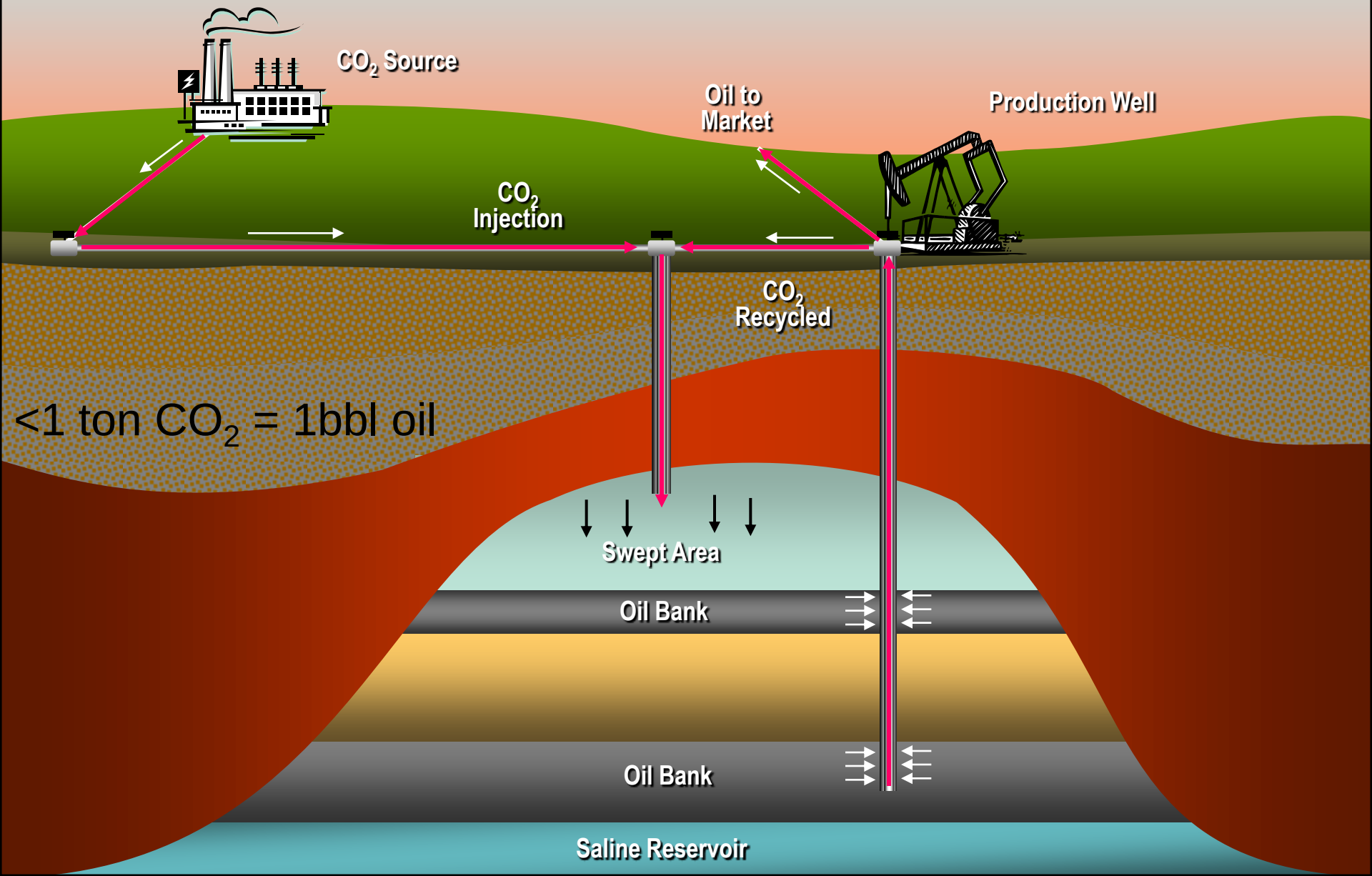


Drivers & R&D objectives

One GREAT Team — Southern Company Generation

- **CCS Technology Drivers**
  - Compliance with carbon legislation or GHG environmental regulation
  - 200 years of domestic fossil fuel resources
  - Fossil-fuel generation assets/new environmental controls
  - Challenging regional renewable portfolio
  - World class sequestration geology with strong demand for CO_2-EOR
- **CCS Research Objectives**
  - Demonstrate commercially viable option that supports investment decision by 2020
    - Support roll-out of innovative new technology
    - Broaden list of candidate sites/geologies/use options for CO_2
    - Outreach & education with CCS stakeholders

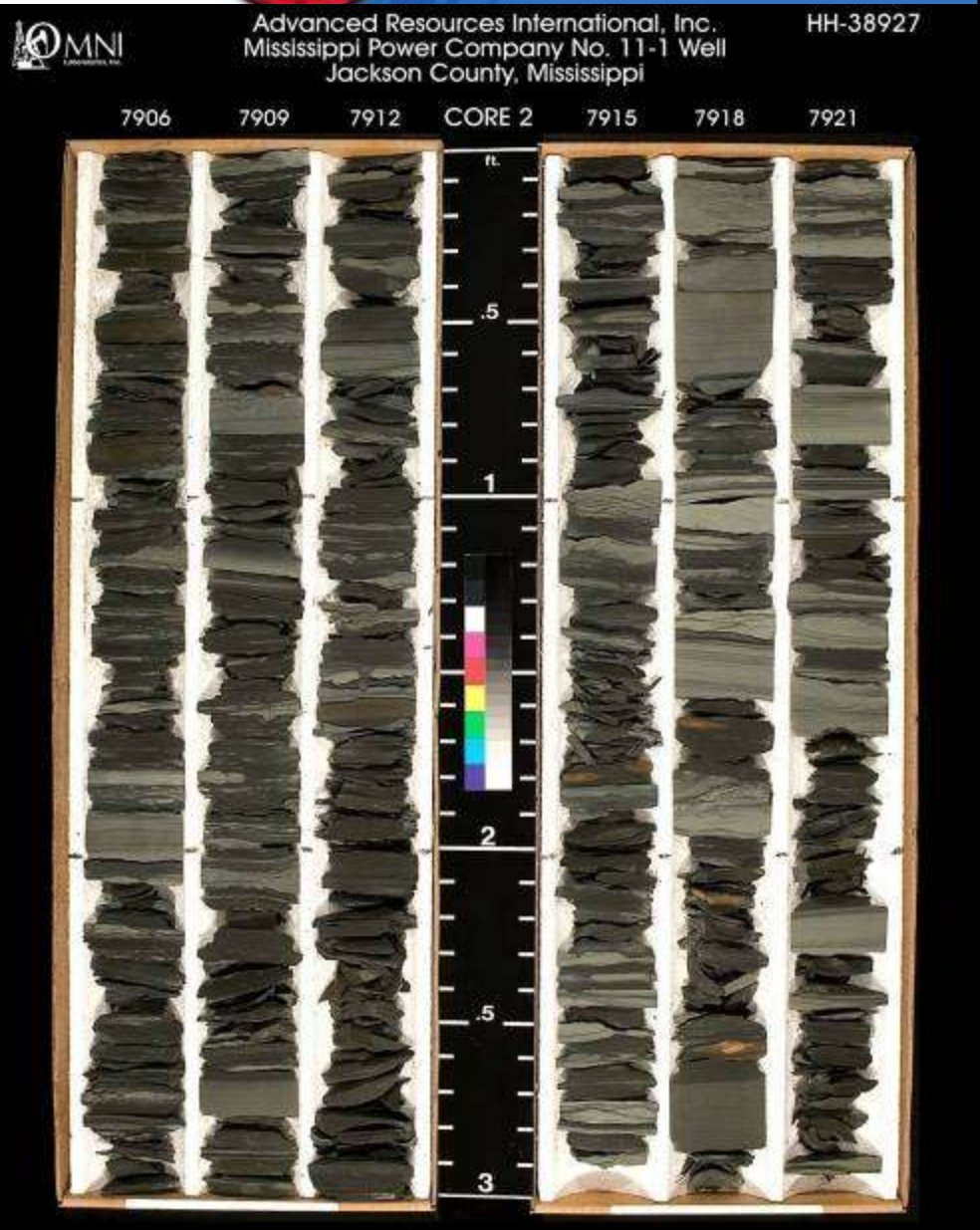
Integrating CO_2-EOR and geologic storage



Saline reservoir pilot injection

Geologic drill cores

One GREAT Team — Southern Company Generation



Coal seam pilot injection

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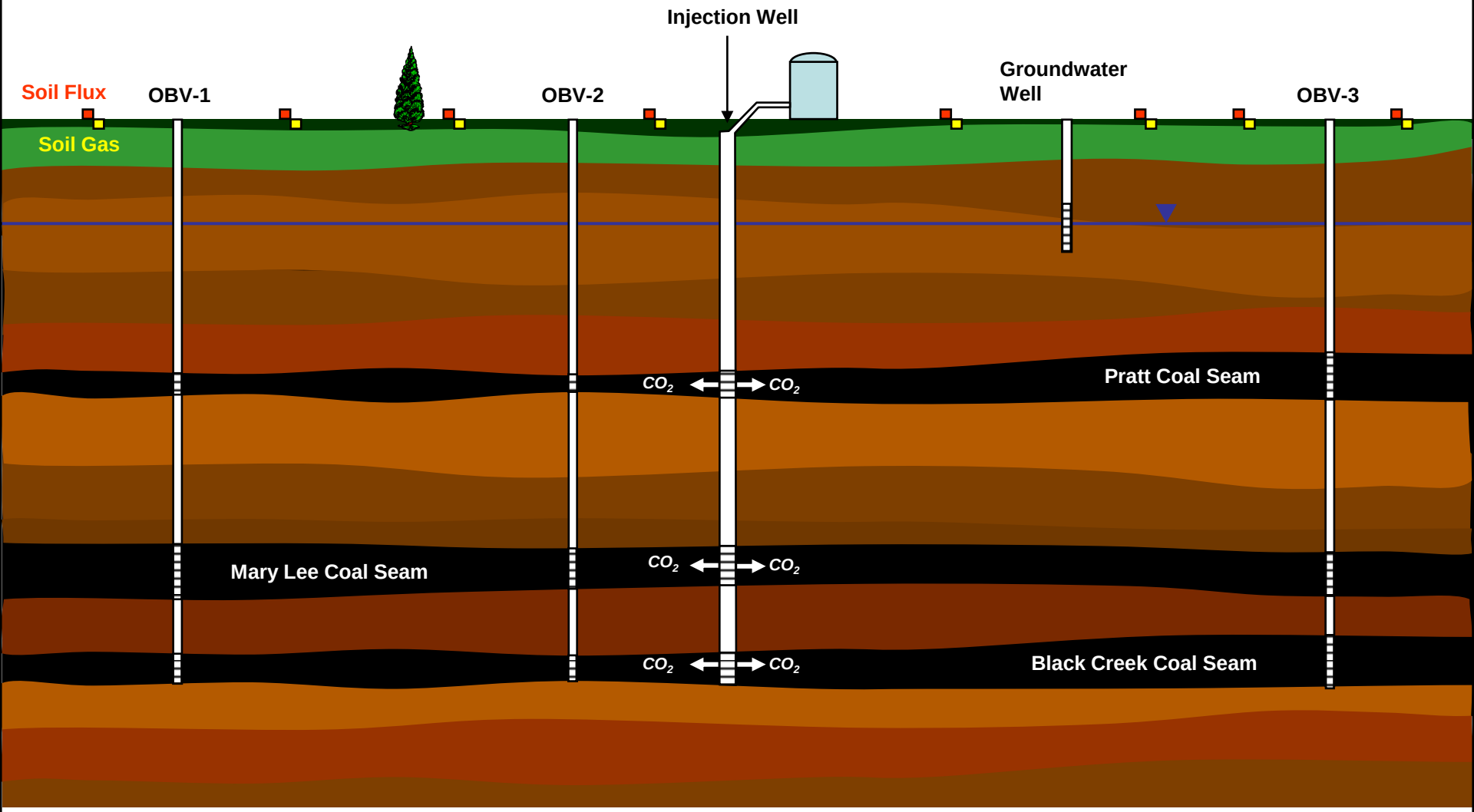
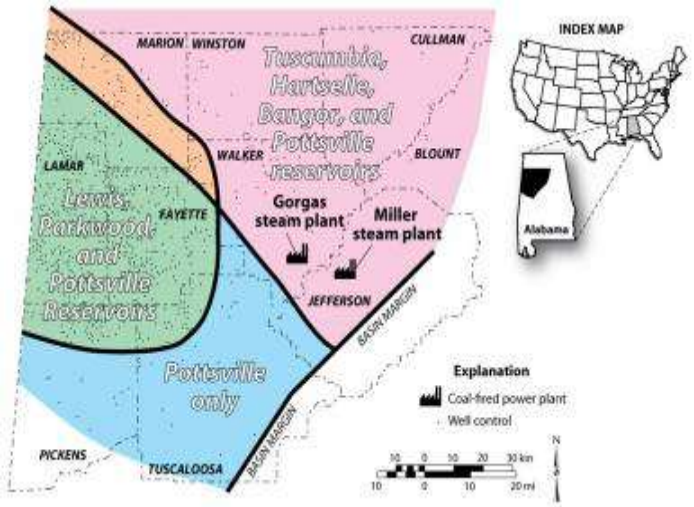


Gorgas site characterization



Drill exploratory stratigraphic test well
Sample reservoirs and seals
Shoot 2-D seismic profiles
Borehole logging and well-testing techniques
Laboratory analysis/reservoir simulation

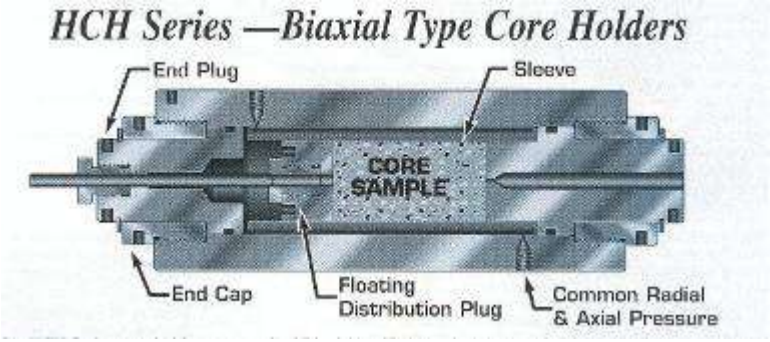
Cap rock integrity lab

One GREAT Team — Southern Company Generation

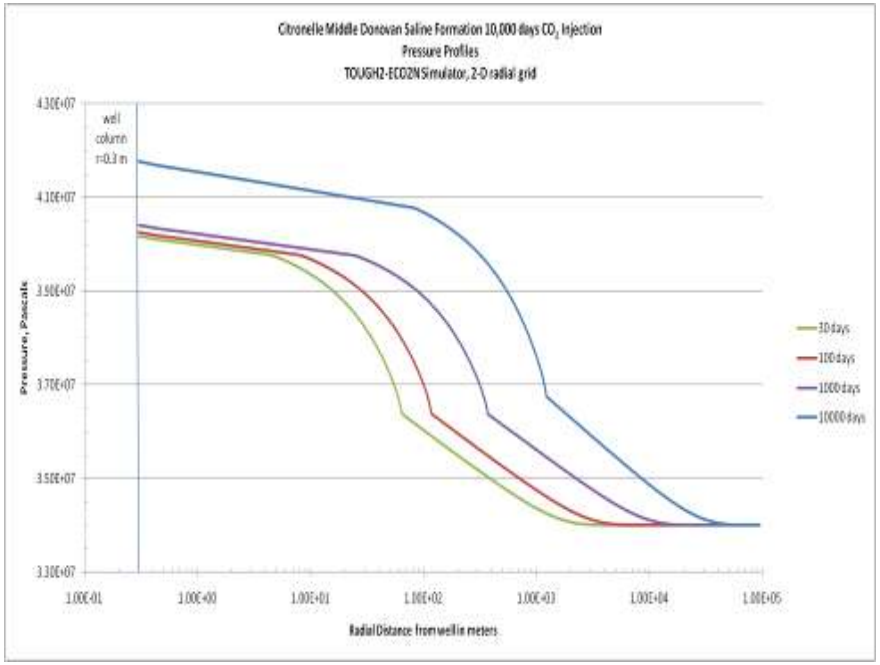
Research supported by:

- U.S. Department of Energy
"Geologic Sequestration Training and Research"

- Southern Company
"Geologic Carbon Sequestration: Cap Rock Integrity Laboratory“



- Located at the University of Alabama at Birmingham – Department of Mechanical Engineering (Dr. Peter Walsh)



Purpose:

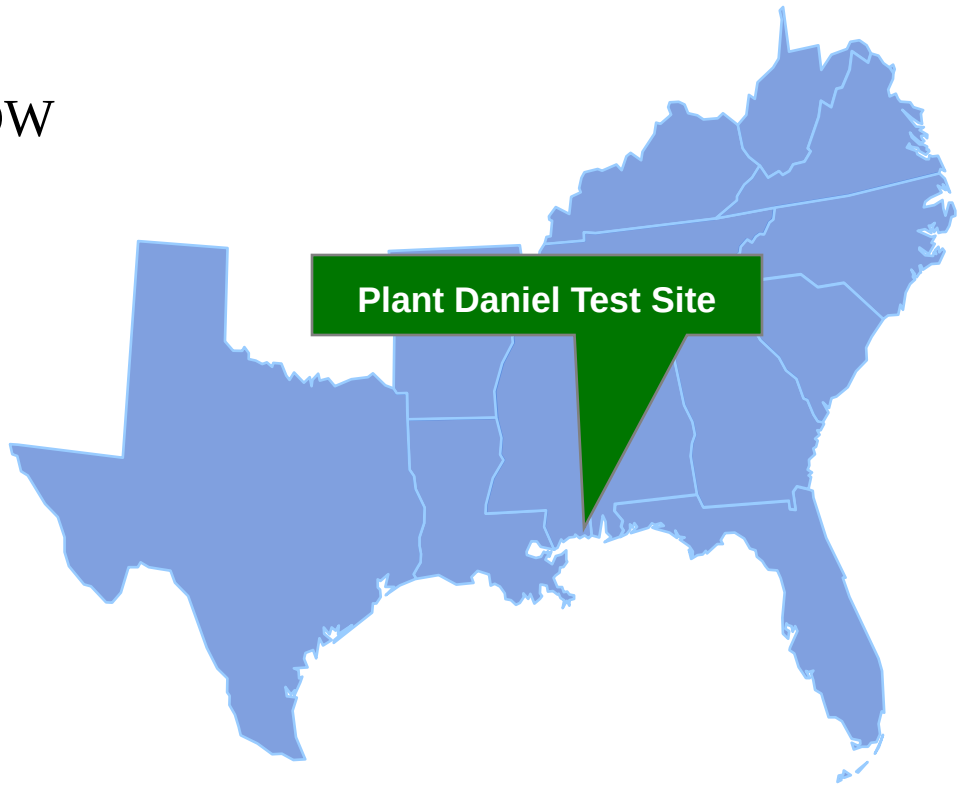
- Long-term storage integrity

- Reassure stakeholders that geologic sequestration is safe and secure.

- Regulation of injection pressure

CO_2 in groundwater study

- **Scope of Work**
  - Simulate CO_2 intrusion into USDW
  - Observe effects in the field
  - Model experiment
- **Purpose of Study**
  - Address stakeholder concerns
  - Identify indicator parameters
  - Understand abatement options



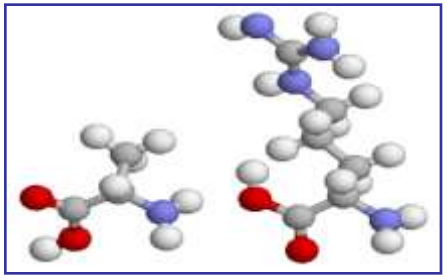
Lab studies and modeling suggests that CO_2 intrusion into aquifers may mobilize naturally-occurring metals and compromising quality of water. Field pilot projects provide field test-beds to understand the reality of this issue.

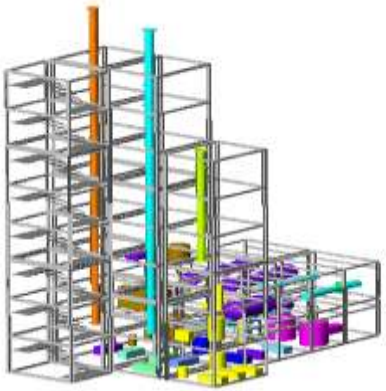
National Carbon Capture Center

One GREAT Team — Southern Company Generation

- Unique flexible testing facility where new processes can be tested on coal derived gas at various scales.
- A technology development facilitator by providing facilities for scale-up from bench-top to engineering-scale.
- Include a wide variety of participants and partners. Find “Best-in-class” Technology.
- Deliver innovation via a collaborative project portfolio that provides an accelerated pathway to cost-effective CO_2 capture technology for coal fueled power production.

U.S. Department of Energy
National Carbon Capture Center
at the Power Systems Development Facility
PARTICIPANTS:
NETL, Southern Company, EPRI, American Electric Power, Luminant, Peabody, ACI Arch Coal Inc., RioTinto, NRG
Managed by Southern Company Services, Inc.





http://www.nationalcarboncapturecenter.com

Commercial Clean Coal

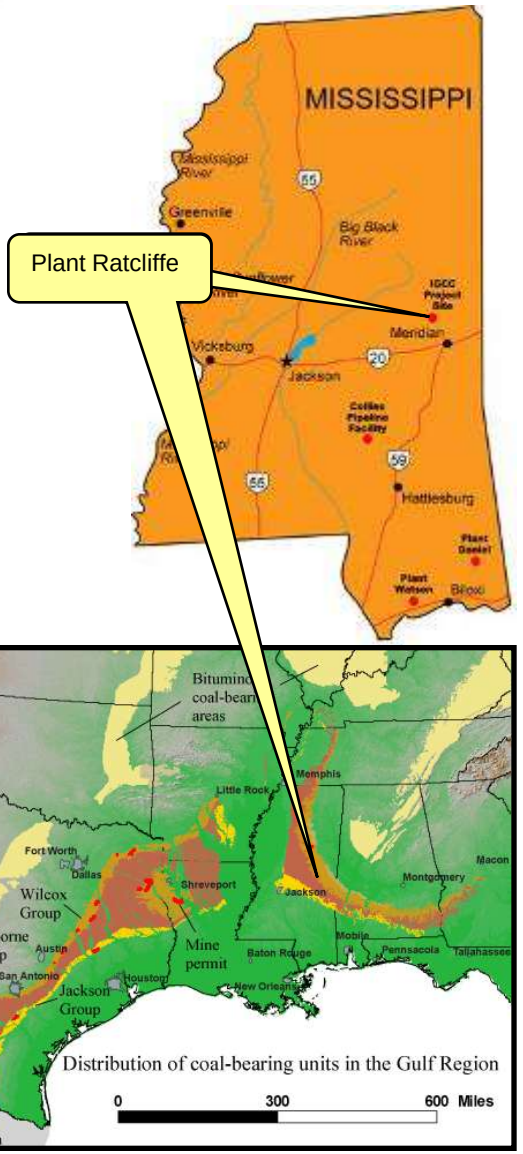
One GREAT Team — Southern Company Generation

Demonstrating CCS with IGCC plus EOR in Mississippi

- 2x1 Integrated Gasification Combined Cycle
  - 582 MW peak and 524 MW on syngas
  - **~65% CO_2 capture** (~800 lb/MWhr emission rate/equivalent to NGCC)
  - Mine mouth lignite – NG Backup
- Owner & operator: Mississippi Power
- Over $2 billion capital investment
- Commercial operating date: May 2014

Captured CO_2 used for EOR (3.4 MMt/yr)

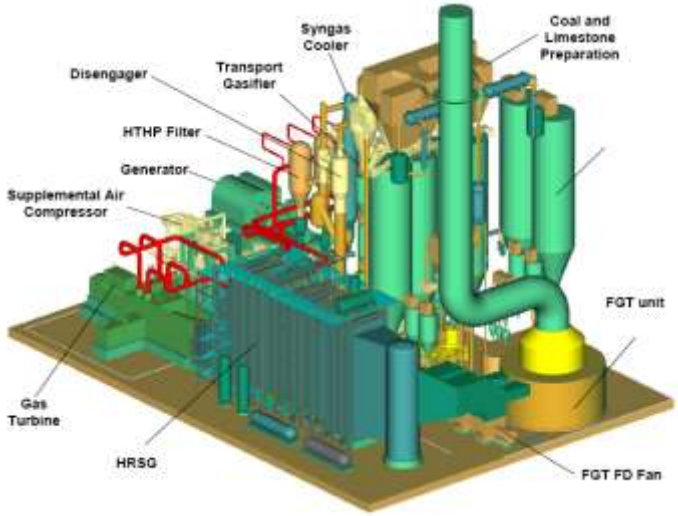
- Mississippi Public Service Commission certificate issued June 3, 2010



TRIG™ Gasification Process

One GREAT Team — Southern Company Generation

- Transport Integrated Gasification

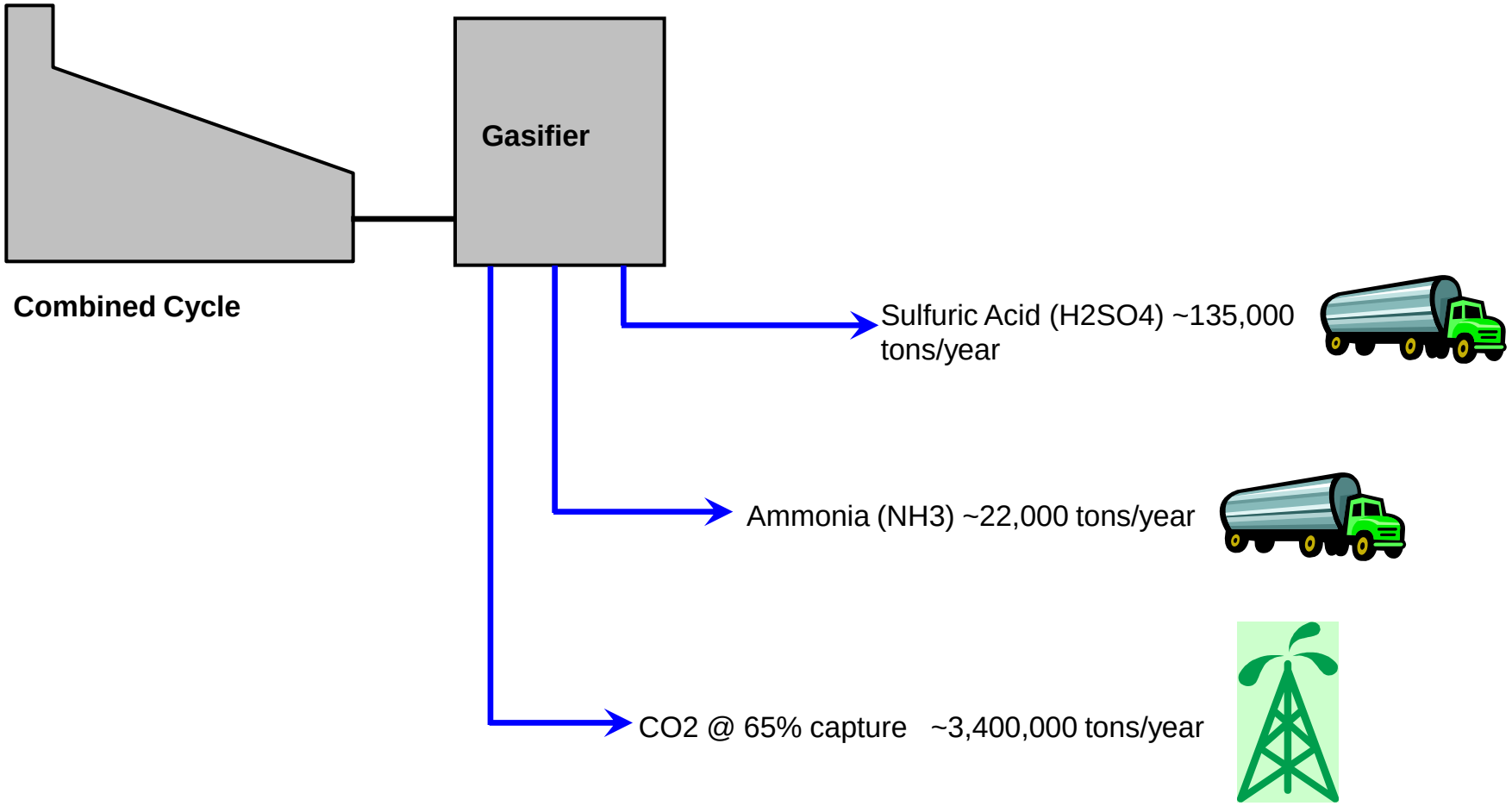


- Product of more than 15 years research
- Developed at the Power Systems Development Facility (PSDF) in Wilsonville, Alabama; now the National Carbon Capture Center
- Sponsored by the DOE, Southern Company and KBR

IGCC By-Products

One GREAT Team — Southern Company Generation

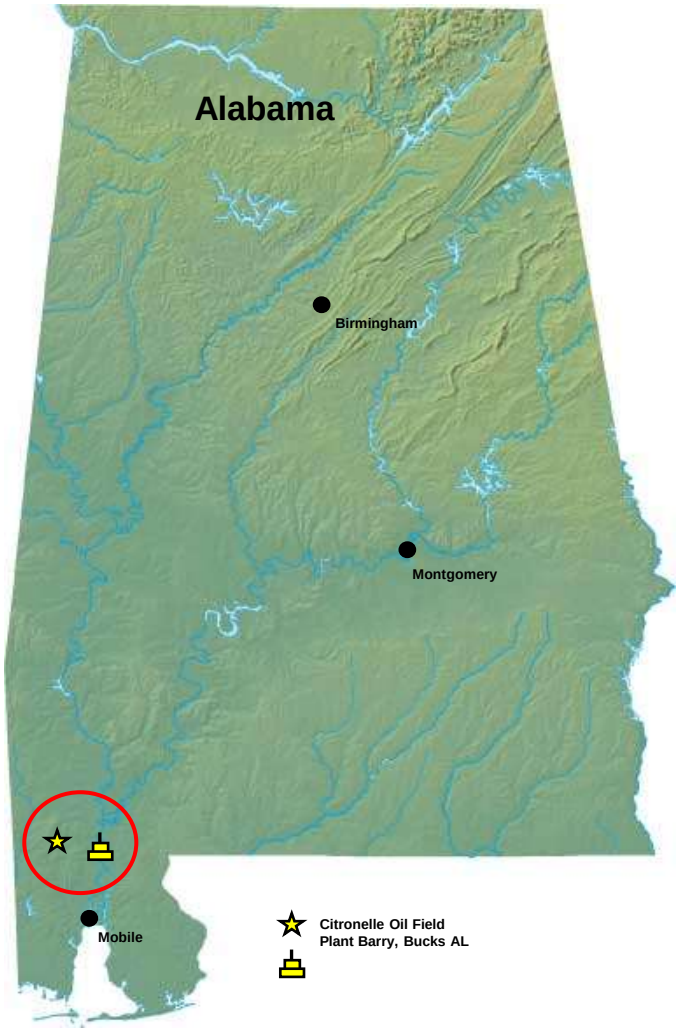
Integrated Gasification Combined Cycle



Barry CCS Demo Overview

One GREAT Team — Southern Company Generation

- Fully integrated CO_2 capture, transport and storage project
- Construct and operate a 25 MW equivalent CO_2 capture unit at Alabama Power's (Southern Co.) Plant Barry
- Construct and operate a 12 mile CO_2 pipeline that will transport CO_2 from Plant Barry to the Citronelle Dome
- Inject 400,000 metric tons of CO_2 into the Paluxy Formation (saline) over 2 to 3 years
- Conduct 3 years of monitoring after CO_2 injection and then close the site



Diverse Project Team

One GREAT Team — Southern Company Generation

Capture

SOUTHERN COMPANY

- Permitting
- Plant Integration & Construction
- Site Host

Mitsubishi Heavy Industrie

- Design
- Technology Provider
- Advanced Amines

EPRI ELECTRIC POWER RESEARCH INSTITUTE

- Economic Evaluation
- Knowledge Transfer
- 3rd Party Evaluation

Transport

SOUTHERN COMPANY

ENTRIX — Down to Earth. Down to Business.

- NEPA Preparation

ep Southern Natural Gas — an El Paso company

Denbury Resources — DRI

- Pipeline Design
- Pipeline Permitting & Construction
- Field Operations

Storage

DOE — NETL

SO. STATES ENERGY BOARD — SSEB

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Advanced Resources International — Advanced Resources International, Inc.

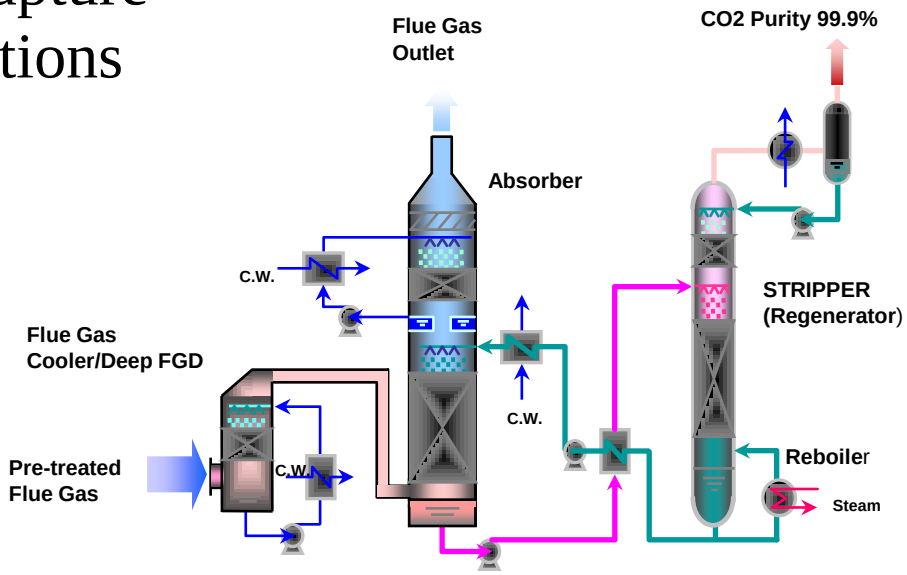
- UIC Permitting
- Reservoir Modeling
- Geologic Modeling
- Field Operations
- Public education/ outreach
- MMA Activities

Denbury Resources — DRI

- Field Operations
- Site Prep/ Drilling Contractors
- Site Host

Capture Scope & Objectives

- Scope:
  - Demonstrate post-combustion capture of CO_2 from Plant Barry flue gas using MHI's advanced amine process
- Objectives:
  - Demonstrate integrated CO_2 capture under realistic operating conditions typical of a coal-fired plant
  - Economics: Establish realistic values for the energy penalty and implementation costs
  - Test reliability of solvent-based capture



Simplified schematic post-combustion solvent process

Capture Plant Update

One GREAT Team — Southern Company Generation

2010

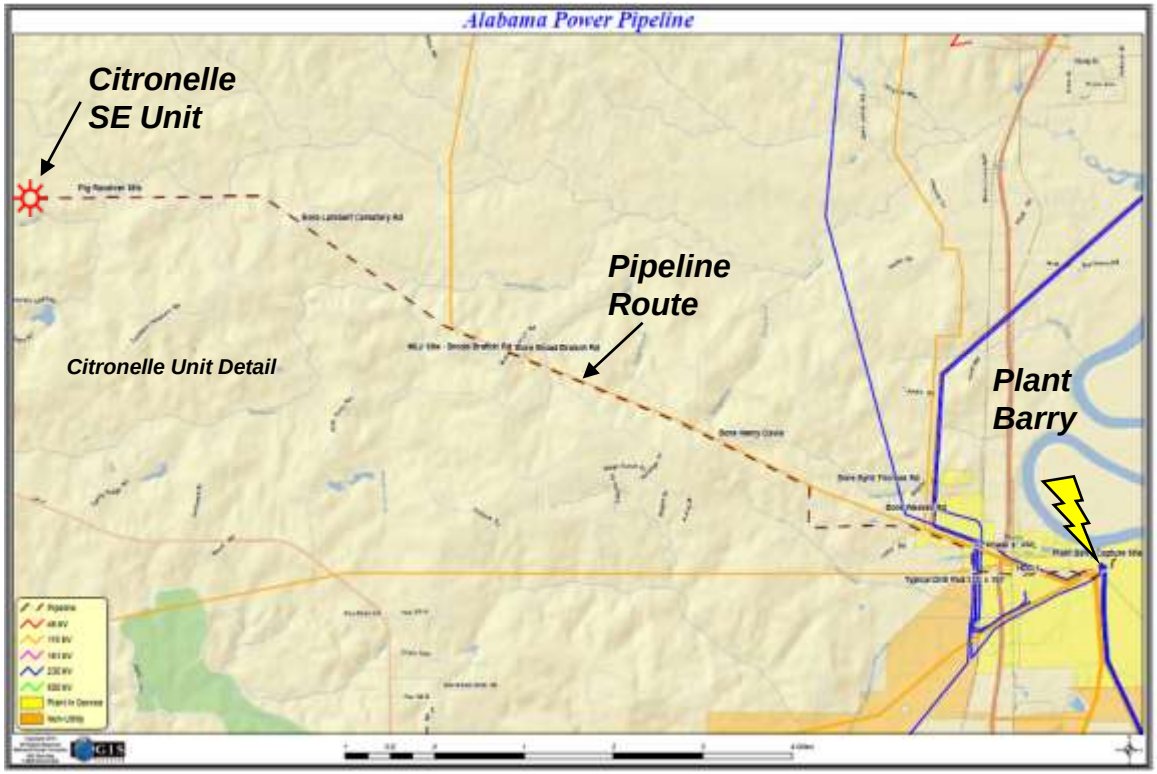
2011

Photos Courtesy of Southern Company

Capture plant & compressor started operations on June 4

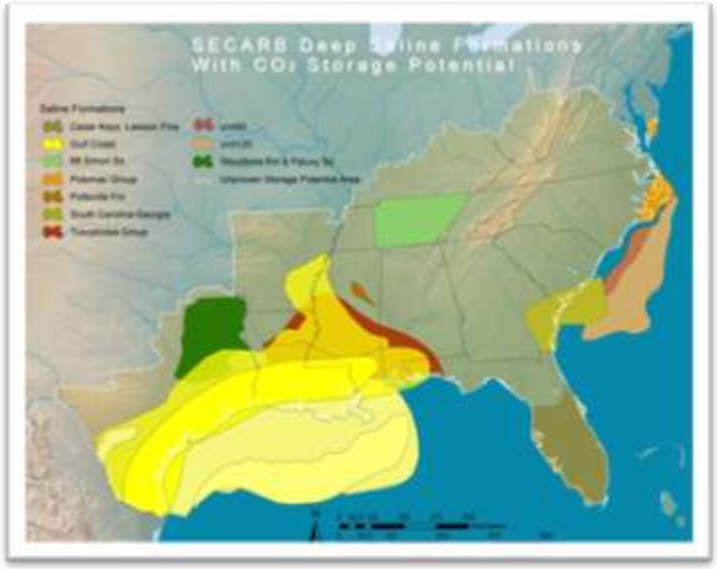
CO_2 Pipeline Overview

- Approx. 12 mi to the SE operators unit in Citronelle Field
- Right-of-Way
  - Utility corridor for 80%; 9 land owners
- Pipe specifications
  - 4-in pipe diameter
  - X70 carbon steel
  - DOT 29 CFR 195 liquid pipeline; buried 3 feet with surface vegetation maintenance
  - 14 directional drills under sensitive
  - Purity is 97% dry CO_2 at 115ºF, 1,500 psig

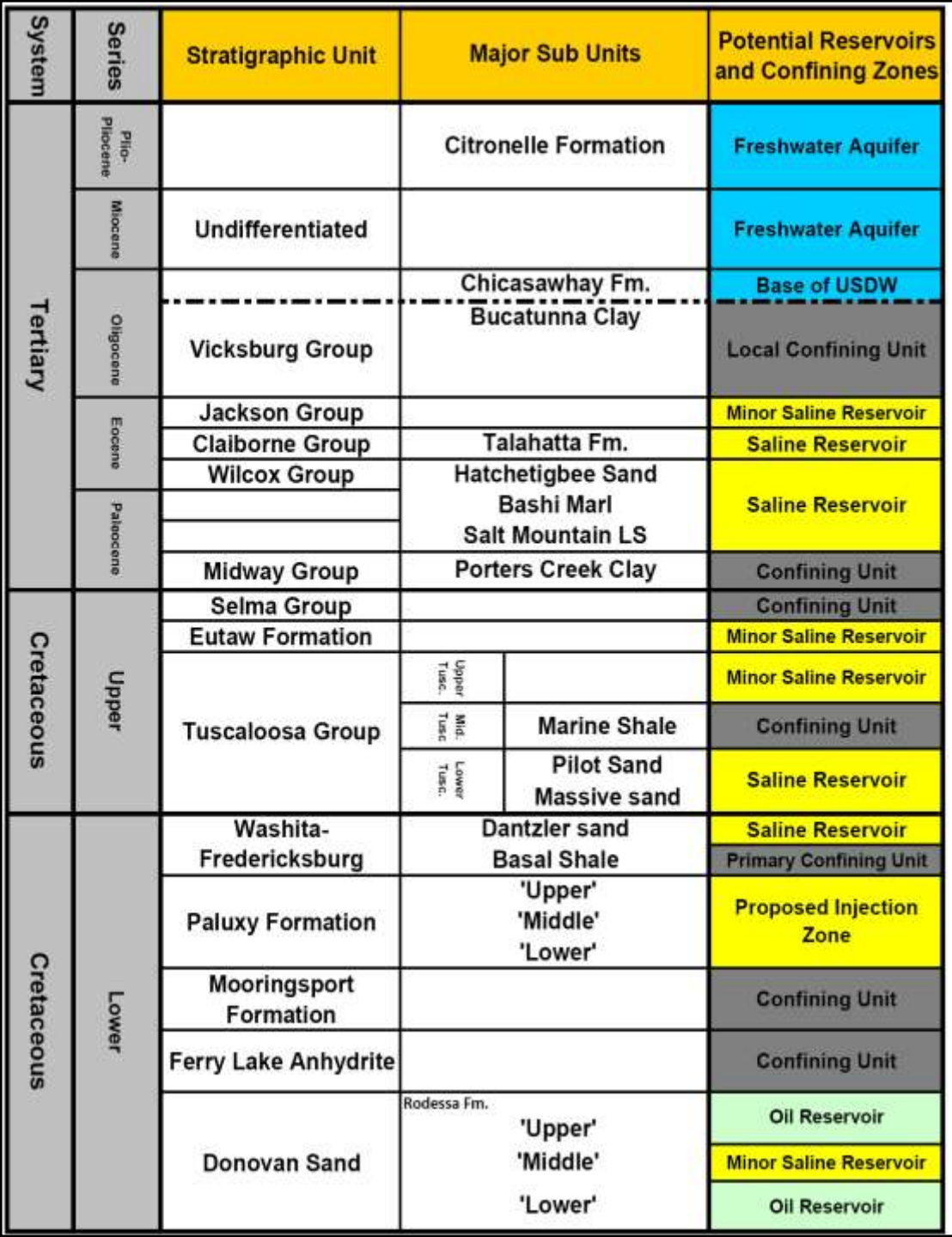


- Right-of-way habitat (pine forest in the Mobile River watershed; some wetlands)

Storage Scope & Objectives



- Scope:
  - Demonstrate safe, secure CO_2 injection and storage in regionally significant saline reservoirs in the southeast U.S. region
- Objectives:
  - Identify and mitigate potential leakage risk
  - Evaluate local storage capacity, injectivity and trapping mechanisms for the Paluxy Formation (saline reservoirs)
  - Demonstrate how a saline reservoir's architecture can be used to maximize CO_2 storage and minimize the areal extent of the CO_2 plume
  - Test the adaptation of commercially available oil field tools and techniques for monitoring CO_2 storage



System	Series	Stratigraphic Unit	Major Sub Units	Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation	Freshwater Aquifer
	Miocene	Undifferentiated		Freshwater Aquifer
	Oligocene		Chicasawhay Fm.	Base of USDW
		Vicksburg Group	Bucatunna Clay	Local Confining Unit
	Eocene	Jackson Group		Minor Saline Reservoir
		Claiborne Group	Talahatta Fm.	Saline Reservoir
		Wilcox Group	Hatchetigbee Sand	Saline Reservoir
	Paleocene		Bashi Marl	
			Salt Mountain LS	
		Midway Group	Porters Creek Clay	Confining Unit
Cretaceous	Upper	Selma Group		Confining Unit
		Eutaw Formation		Minor Saline Reservoir
		Tuscaloosa Group	Upper Tusc.	Minor Saline Reservoir
			Mid. Tusc. — Marine Shale	Confining Unit
			Lower Tusc. — Pilot Sand / Massive sand	Saline Reservoir
Cretaceous	Lower	Washita-Fredericksburg	Dantzler sand	Saline Reservoir
			Basal Shale	Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'	Proposed Injection Zone
		Mooringsport Formation		Confining Unit
		Ferry Lake Anhydrite		Confining Unit
		Donovan Sand	Rodessa Fm. 'Upper'	Oil Reservoir
			'Middle'	Minor Saline Reservoir
			'Lower'	Oil Reservoir

One GREAT Team — Southern Company Generation

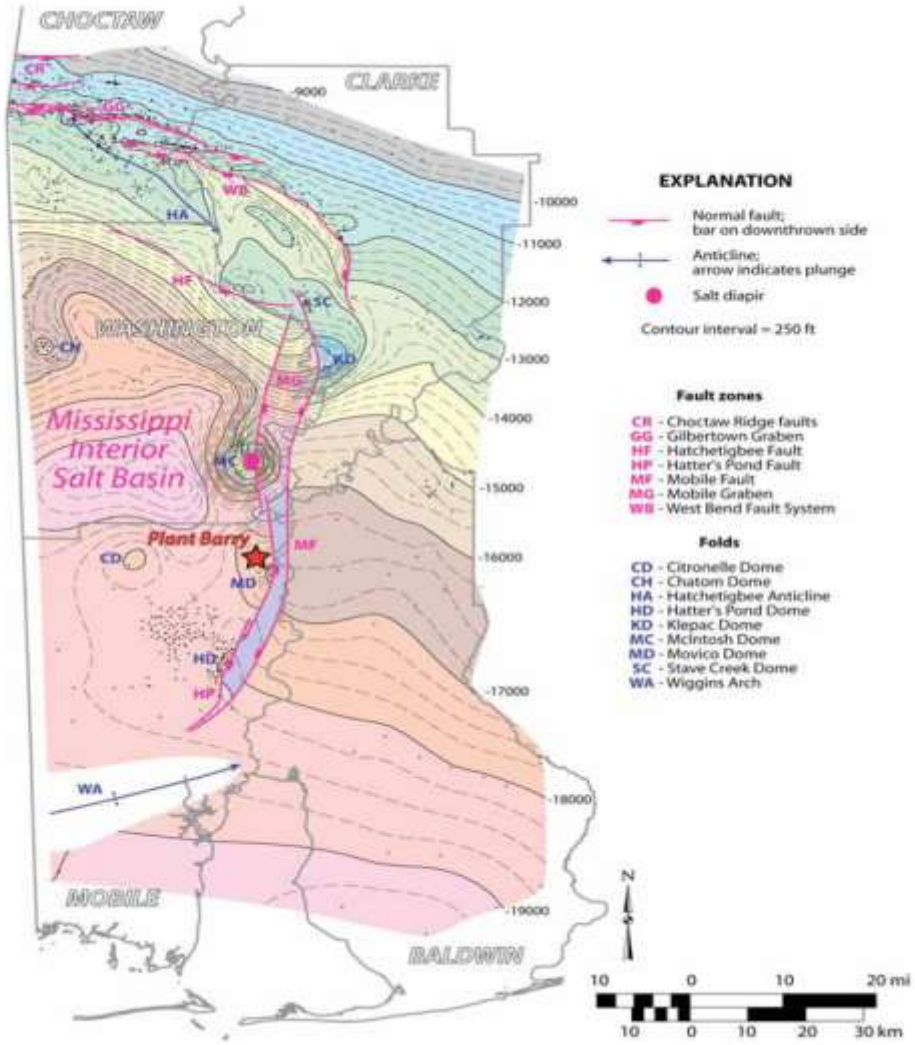
Stacked Storage Reservoirs

Tertiary Injection Zone (Eutaw Fm.)

Secondary Injection Zone (Tuscaloosa Fm.)

Proposed Injection Zone (Paluxy Fm.)

Citronelle Dome



Sequestration site is on the southeast flank of Citronelle dome in the Paluxy Formation:

- Proven four-way closure
- No evidence of faulting or fracturing
- Large storage capacity with good permeability and porosity
- Multiple local and regional confining units between injection targets and base of USDW
- Historic oil and gas wells provide available geologic information

Esposito R.A., Pashin J.C., Walsh P.M. (2008) Citronelle Dome: A Giant Opportunity for Multi-Zone Carbon Storage and Enhanced Oil Recovery in the Mississippi Interior Salt Basin of Alabama. Environmental Geosciences, v 15, p. 53-62.

Geologic Storage Update

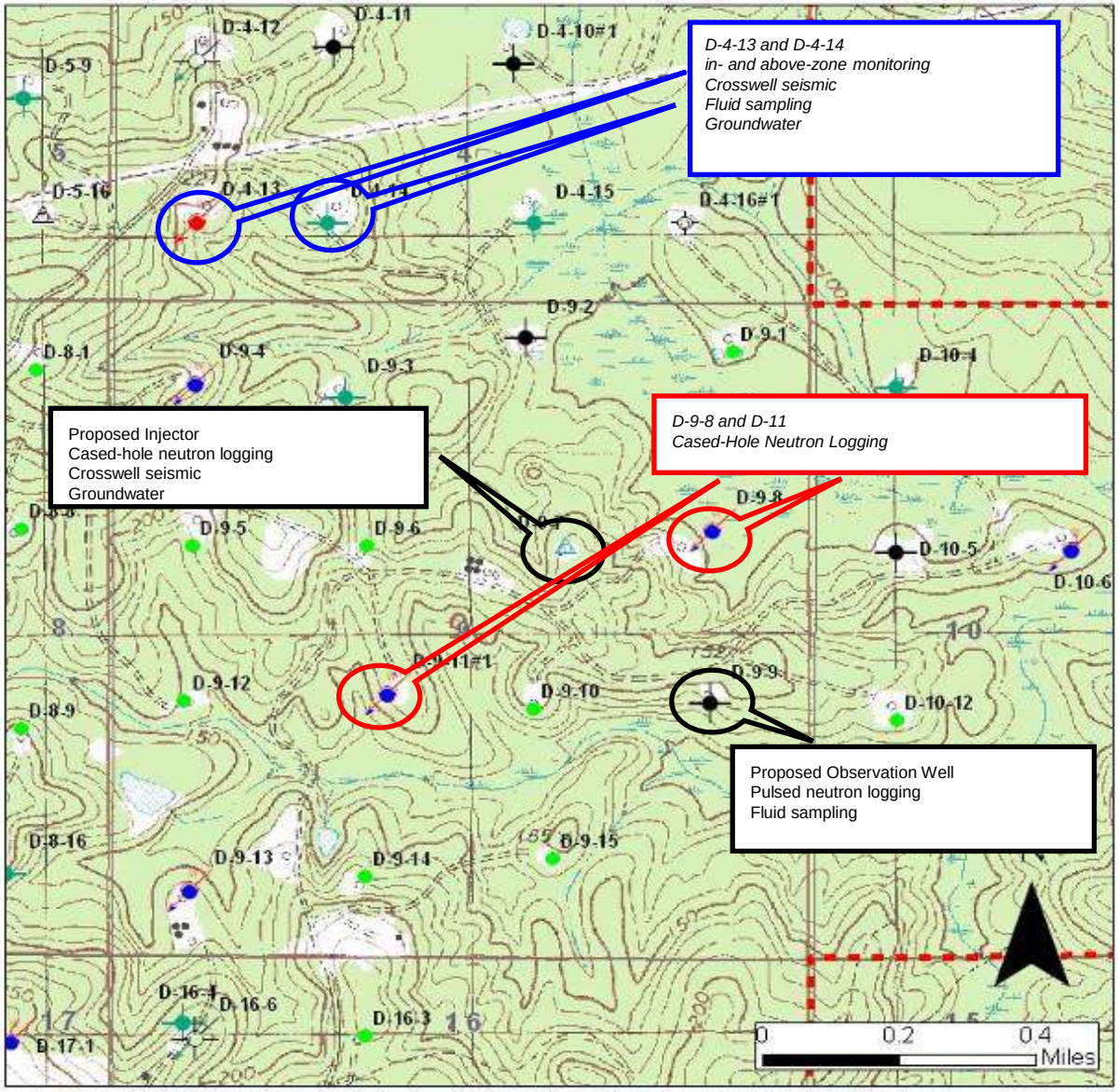
One GREAT Team — Southern Company Generation

- Characterization Well D9-8#2 started 31-Dec-2010
  - 32 days to drill and install well
  - Total depth 11,817 ft (3,602 m)
  - 98 feet (30 m) of whole core
  - 45 percussion sidewall cores
  - Well logs (Triple Combo, MRI, Mineralogy, Dipole Sonic, CBL)
- Two injection wells to be installed upon receiving UIC permit

Rig on location at well D9-8#2

Characterization well successfully completed January 31, 2011

CO_2 Injection & Monitoring



- Groundwater
- Cross-well Seismic
- Vertical Seismic Profiling
- P&T (in-zone and above-zone)
- Fluid Sampling
- RST logging
- Tracers

Lessons learned … start early